Nondestructive Evaluation of Adhesive Bond Strength by Ultrasonic Phase Measurements

Completed Technology Project (2016 - 2020)

Project Introduction

As space technology advances, so does the desire to use lightweight advanced composite structures. Composite structures offer many advantages to their metal counterparts in terms of weight, strength, and durability. However, unlike in metal structures where bolting and riveting are widespread, adhesive bonding is the preferred method to join two composite materials. Consequently, a method to quantitatively determine the strength of an adhesive bond must be used to ensure strength and stability of adhesively bonded structures. Unfortunately, conventional nondestructive evaluation techniques have proved unable to ensure detection of weak bonds or quantitatively measure bond strength. Therefore, a new nondestructive technique is being proposed for quantitatively measuring adhesive bond strength. This technique uses an ultrasonic signal and an interferometric constant frequency pulsed phased-locked loop (CFPPLL) circuit to measure the phase response of a bonded region due to thermal stress. Theoretical research has shown that the thermal properties of a bonded structure should have a strong relationship with the quality of the adhesive bond. These properties should be measurable using this ultrasonic phase-based technique. Another technique that relies upon the frequency dependence of the reflection coefficient of the bonded interface will also be evaluated using the CFPPLL instrument. The sensitivity of this instrument should also allow it to detect very weak or kissing bonds that have been previously undetectable. Through this research project, these techniques will be developed and tested using a variety of adhesives and bonded materials, and their ability to detect each of the major types of bond defects will be examined. Additionally, the sensitivity of the technique to very thin bonds will be studied. Mathematical models to describe the acoustic responses to stresses in a bonded region are also being developed. Adhesive bonds under failure loads will also be examined for their phase response to ultrasonic interrogation. Computational modeling will be use to verify these results to promote a better understanding of the mechanics of bond failure to physics at large. In the end, this technique has the potential to advance the use of adhesive bonds and by association, advanced composite structures in space technology design by providing a reliable method of quantifiably measuring adhesive bond strength. This innovation would then allow for more complex, lightweight, and safe spacecraft design.

Anticipated Benefits

In the end, this technique has the potential to advance the use of adhesive bonds and by association, advanced composite structures in space technology design by providing a reliable method of quantifiably measuring adhesive bond strength. This innovation would then allow for more complex, lightweight, and safe spacecraft design.

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Table of Contents

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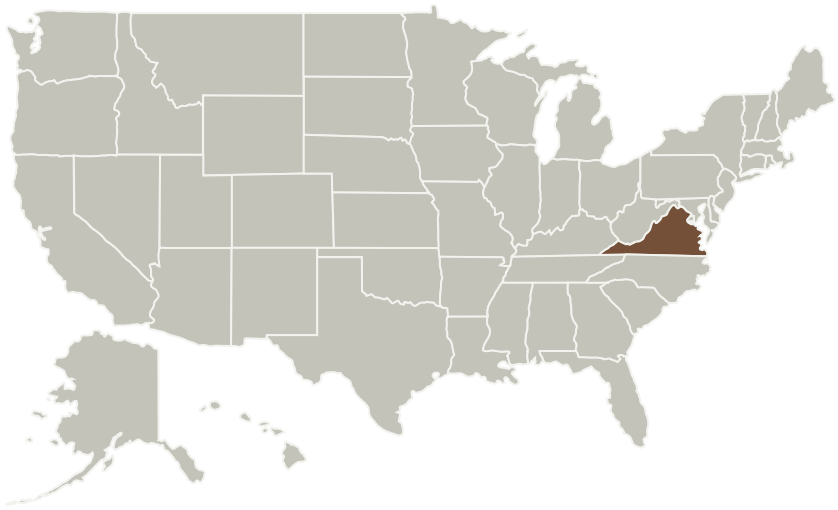
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Virginia-Main Campus	Lead Organization	Academia	Charlottesville, Virginia

Primary U.S. Work Locations
Virginia

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of Virginia-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Mool C Gupta

Co-Investigator:

Harold A Haldren

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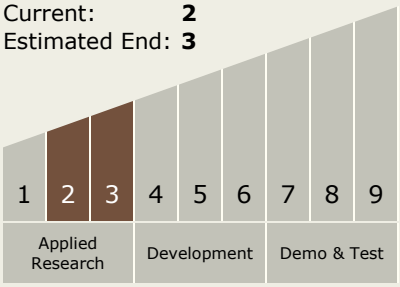
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX13 Ground, Test, and Surface Systems
  - TX13.2 Test and Qualification
    - TX13.2.3 Non-Destructive Inspection, Evaluation, and Root Cause Analysis

Target Destination

Foundational Knowledge